

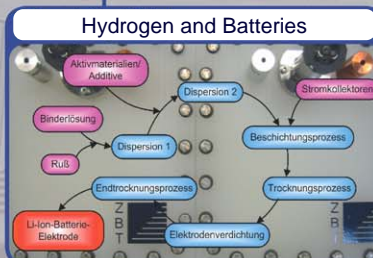
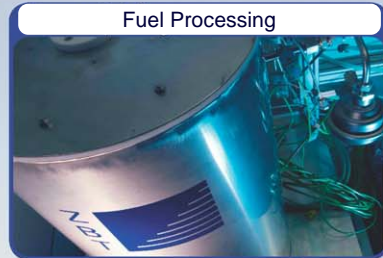
# Alkoholqualität für Brennstoffzellensysteme

## *6. Fachgespräch dezentrale Ethanolerzeugung*

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- Founded 2001
- ca. 100 employees
- R&D focus on industry demand

## Available technologies & competences

- Graphite based bipolar plates
- Metallic bipolar plates
- Stack design (LT/HT PEM)
- Stack operation (H<sub>2</sub>/reformat)
- System integration (H<sub>2</sub>/reformat)




## Additional activities for components, stacks and systems:

- Automated test facilities
- Application oriented testing
- Quality control
- Testing for certificates
- Production technologies



## Worldwide no existing infrastructure for hydrogen

- ⇒ H2 systems for special applications
- ⇒ Upstream reforming process necessary (with water and/or air)
- ⇒ Fuel depending on application and specific infrastructure

Application	Stationary ( $P_{el} \geq 1 \text{ kW}$ )	Mobile ( $P_{el} \approx 0,2 - 5 \text{ kW}$ )	Portable ( $P_{el} \leq 50 \text{ W}$ )
Possible Fuel			
<b>NG</b>	<b>x</b>	<b>x</b>	
<b>LPG</b>	<b>x</b>	<b>x</b>	
<b>Gasoline, Diesel</b>		<b>x</b>	
<b>Methanol</b>		<b>x</b>	<b>x</b>
<b>Biogas</b>	<b>x</b>		
<b>XtL</b>		<b>x</b>	
<b>Biodiesel</b>		<b>x</b>	
<b>Bioethanol</b>	<b>x</b>	<b>x</b>	<b>x</b>

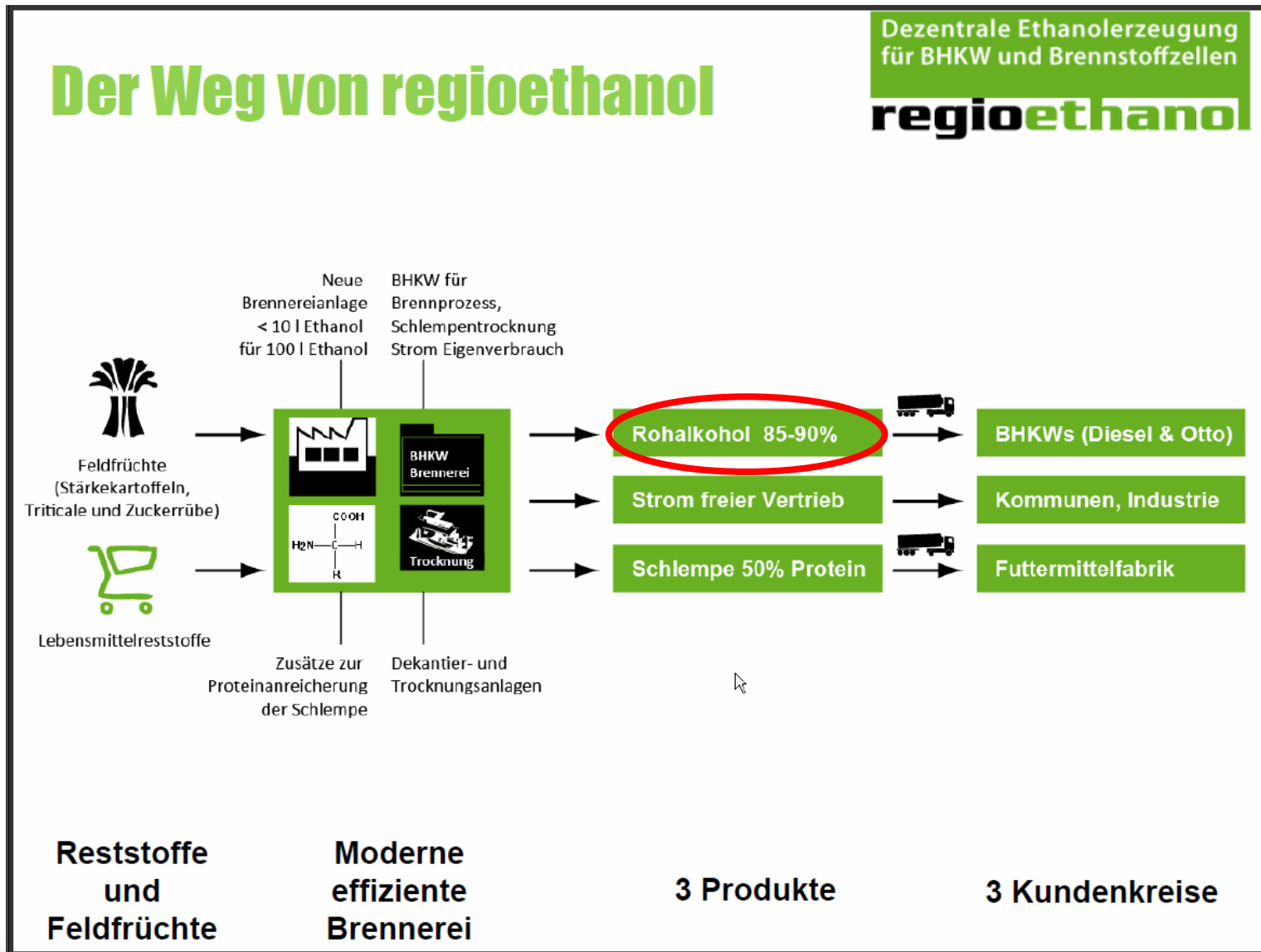
Fotos: Vaillant, Opel, Fraunhofer

## Netzwerk regioethanol (<http://www.regioethanol.net/>)

- Idee
  - Bioethanol-Herstellung aus stärkehaltigen Abfällen wie z.B. Backwaren oder anderen Speiseabfällen oder ungenutzten landwirtschaftlichen Reststoffen in dezentralen Brennereien
- Motivation
  - Verbesserung der wirtschaftlichen Lage der Brennereien
  - Heimische Energiequellen verringern die Abhängigkeit von Importen und erhöhen die Versorgungssicherheit
  - Bildung neuer Industriezweige, neue Perspektiven der Landwirtschaft, Sicherung von Arbeitsplätzen.

## Vorteile von Bioethanol als Brennstoff

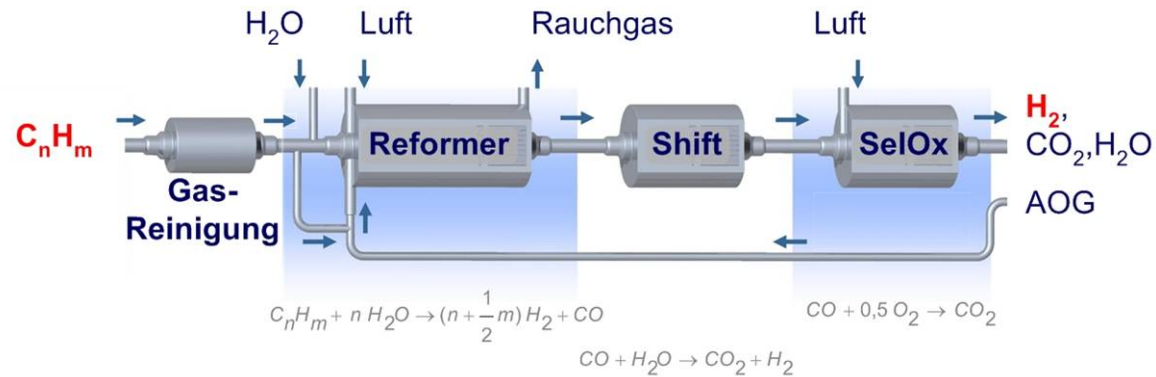
- Nachhaltigkeit (Gewinnung aus Abfällen!)
- Im Vergleich zu Benzin/Ottokraftstoff/MeOH ungiftig
- Bioethanol kann erheblich zur Minderung des Ausstoßes von Klimagasen beitragen



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# Hydrogen generation

Reforming and analytics



## Katalytischer, mehrstufiger Prozess

- Gasreinigung
- Brennstoffumwandlung
- CO-Reinigung

Temperaturen bis 1000 °C

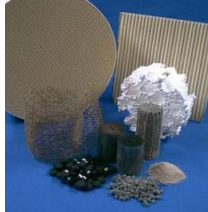
Zahlreiche Wärmeübertrager

Komplexität abhängig von Brennstoffzelle

Reformertypen	xCO	BZ-Typ
	< 50 ppm	NT-PEM
	< 1 %	HT-PEM
	-	NT-PEM
	> 10 %	SOFC



## Catalyst



- Activity & selectivity
- Stability
- Tolerance to harmful gases
- Catalyst carrier
- Reproducibility
- Long term stability

## Reactor



- Process design
- Catalyst integration
- Construction
- Operation mode
- Materials

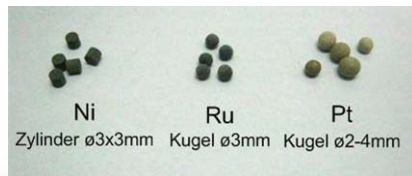
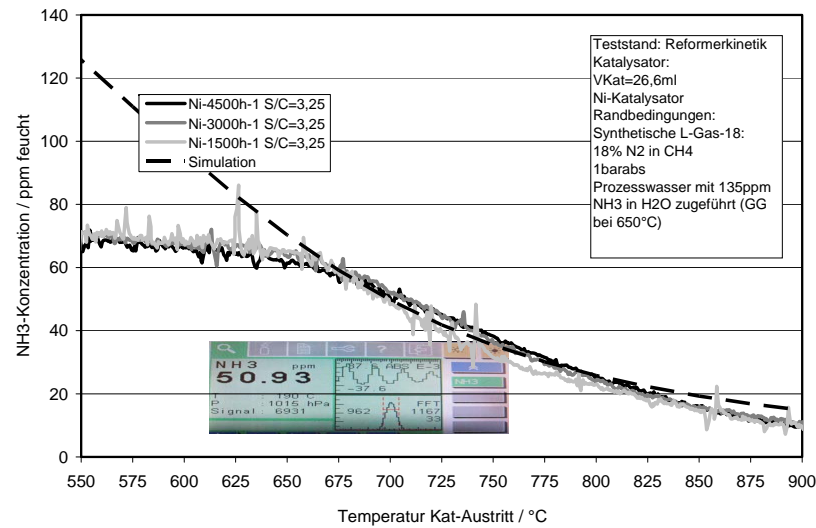
## Reformer system



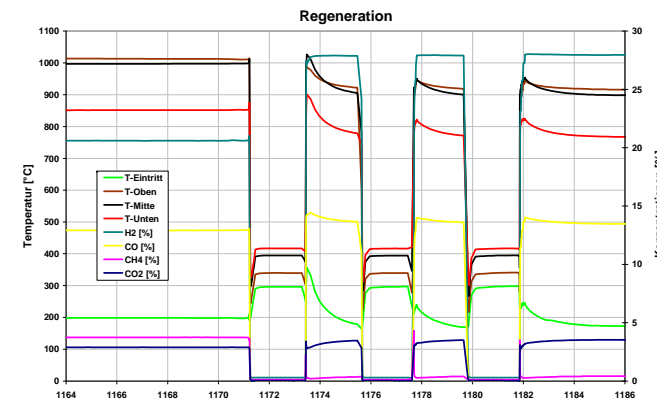
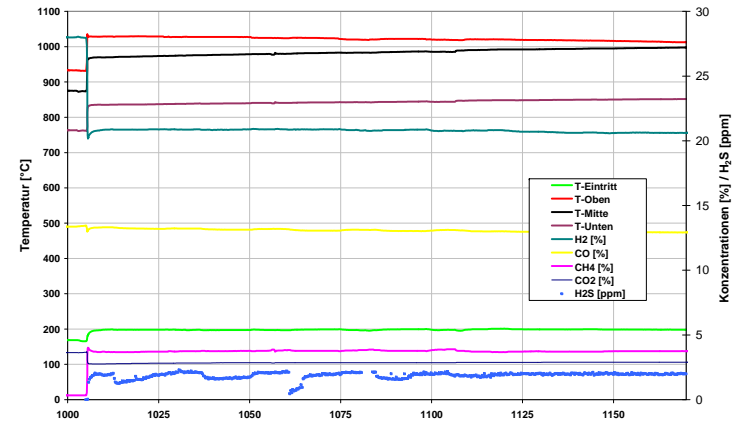
- Interface specifications
- Additional components
- Process optimisation
- Real fuels
- Power density
- Robustness
- Manufacturing
- Costs
- Safety

**Procedural complexity**

## NH<sub>3</sub> production of catalysts for steam reforming of methane

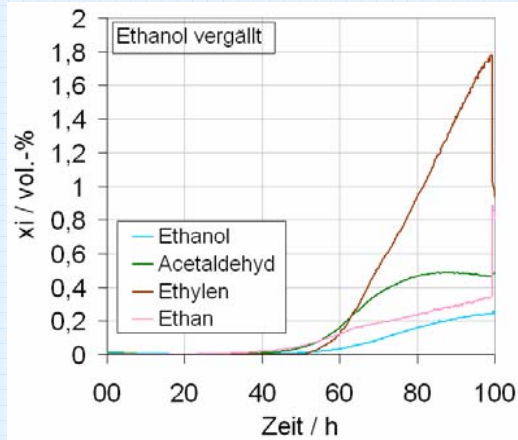
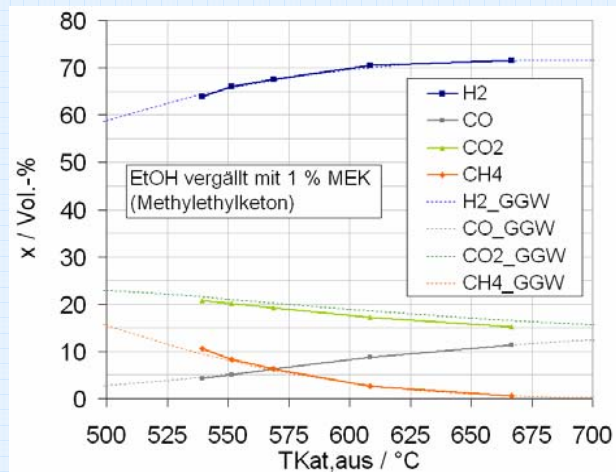
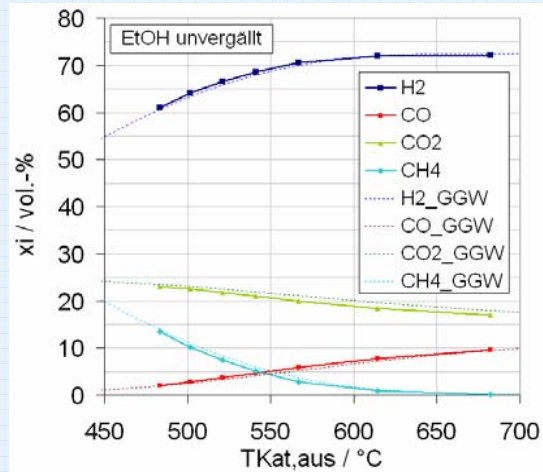


## Sulphur tolerance of catalysts for partial oxidation of NG

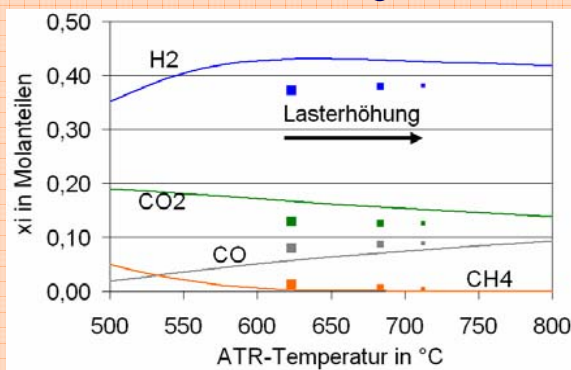


## Activity, stability and by product formation of EtOH reforming

### Steam reforming



### Auto thermal reforming



Automated test stands



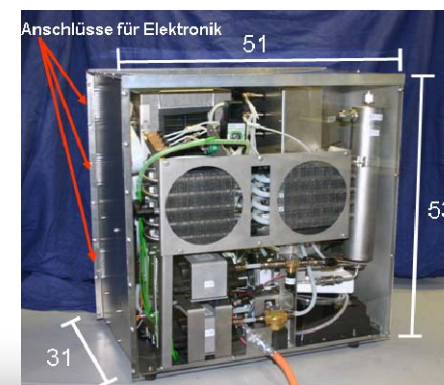
Gas chromatographs

## Applications

- APU (Camping, Yachts)
- Traffic controls signs
- Decentralised energy supply

## Technologies

- Steam, autothermal and membrane reformer
- Fuels: LPG, NG, Ethanol, xtL
- Nominal load: 1 – 3 kW<sub>thH2</sub>
- Efficiency: 67 – 75 %
- Precious metal catalysts on monolithic structures
- Fuel cell types: LT-PEMFC, HT-PEMFC, SOFC
- Patents granted

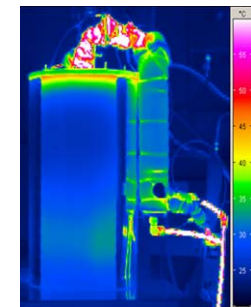
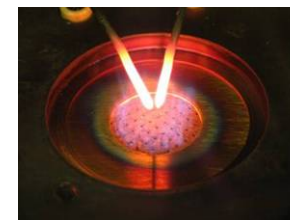
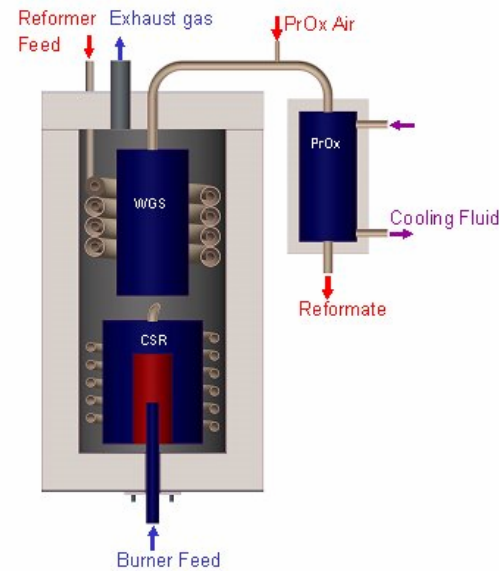


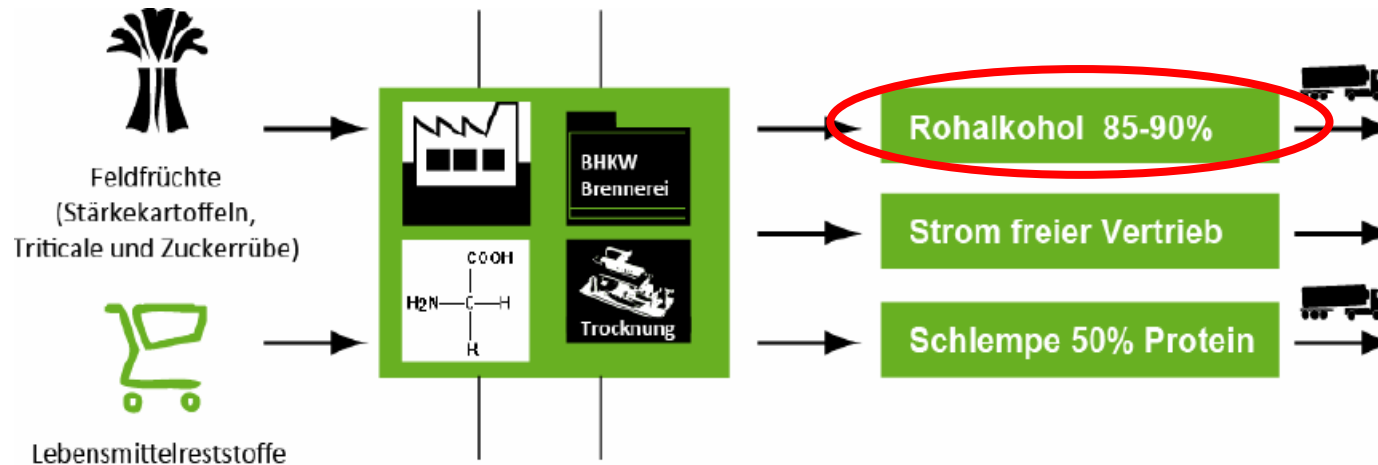
## Applications

- mCHP
- Autarkic energy supply
- Telecommunication
- Backup-Power
- Decentralised hydrogen production

## Technologies

- Fuels: NG, LPG, Biogas, Biomethane
- Steam and combined steam & dry reforming
- Nominal load: 2,5 – 12,5 kW<sub>thH2</sub>
- Efficiency: 75 – 85 %
- Commercial / precious metal catalysts
- Low cost manufacturing
- Fuel cell types: LT-PEMFC, HT-PEMFC & SOFC
- Patents granted in (10 countries in EU, USA, Canada & Korea)

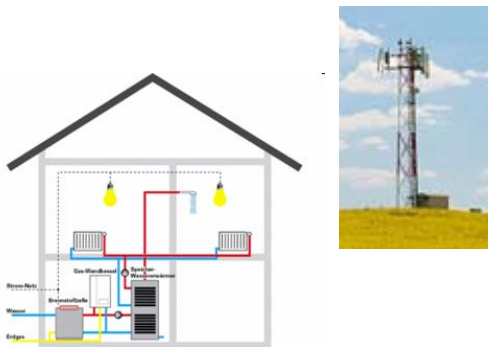




## Offene Fragen

- Zusammensetzung von (Roh-) Alkohol
  - Minorkomponenten
  - Wasser (für Reformierung:  $\text{H}_2\text{O}/\text{C}_2\text{H}_5\text{OH} = 2-4$  [Massenverhältnis])
- Einfluss auf Reformierung & Verstromung in BZ von
  - möglichen Schadkomponenten
  - Vergällungsmittel (MEK ohne Einfluss)

## Anwendungen



## El. Leistung

300-500 W

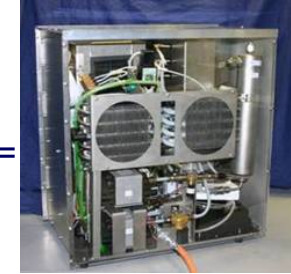
1-2 kW

$\geq 3$  kW

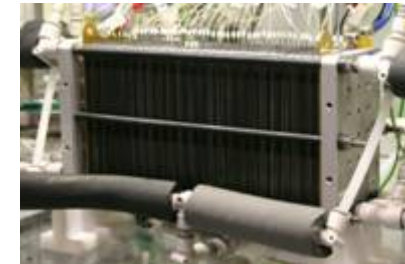
## Brenngasaufbereitung

## Verstromung

Mobiler Stromerzeuger



Mikro-KWK

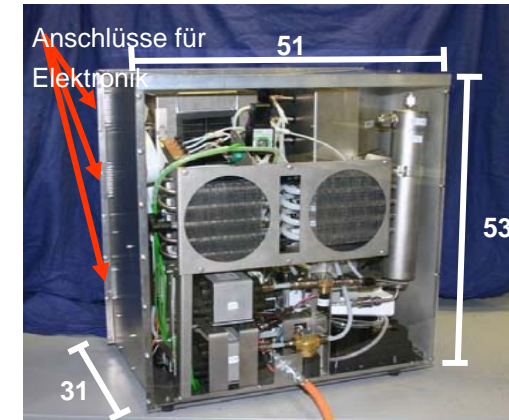
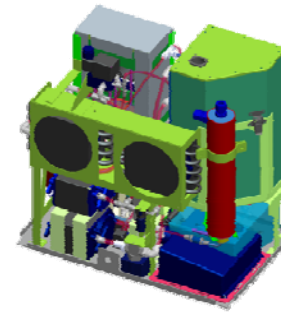
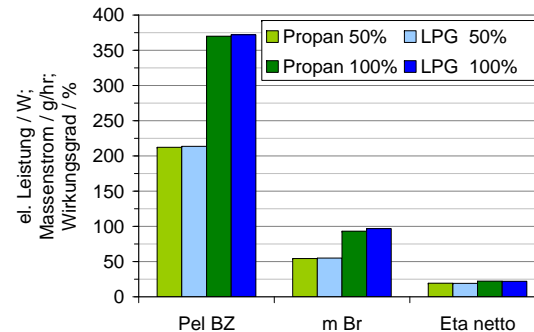


Dezentrale H<sub>2</sub>-Erzeugung



## Basis: LPG-APU

- Brennstoff: LPG
- $P_{el} \approx 300 \text{ W}$
- $\eta \approx 20 \%$
- Gewicht: 45 kg
- Volumen: 85 l



## Vergleich motorischer Generator

- $\eta \approx 17 \%$  (in Teillast stark fallend)
- Hohe Emissionen (Geräusche, Vibrationen, Abgase)

## Anpassungsentwicklung für EtOH

- Katalysatoruntersuchungen
- Anpassung der Wärmeübertrager (u. a. EtOH-Verdampfer)



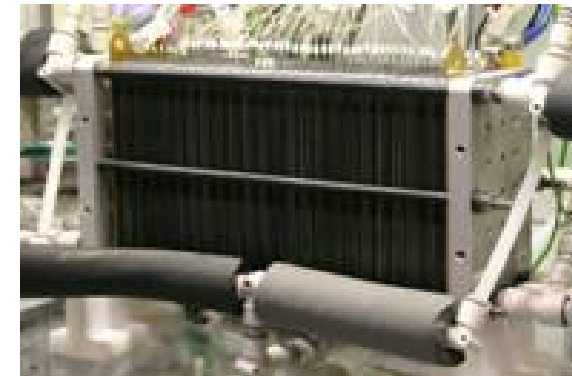
## Brenngasaufbereitung: Dampfreformer für NG, LPG & Biogas

- Nennlast: 2,5 – 12,5 kW<sub>thH2</sub>
- Wirkungsgrad: 75 – 85 %
- Kommerzielle Katalysatoren
- Kostengünstige Fertigung
- BZ-Typen: NT-PEMFC, HT-PEMFC
- Patente erteilt in (10 Länder der EU, USA, Kanada & Korea)



## Wirkungsgradpotentiale

- $\eta_{el} \leq 60 \%$  (abhängig von BZ-Typ)
- $\eta_{Gesamt} \leq 90 \%$

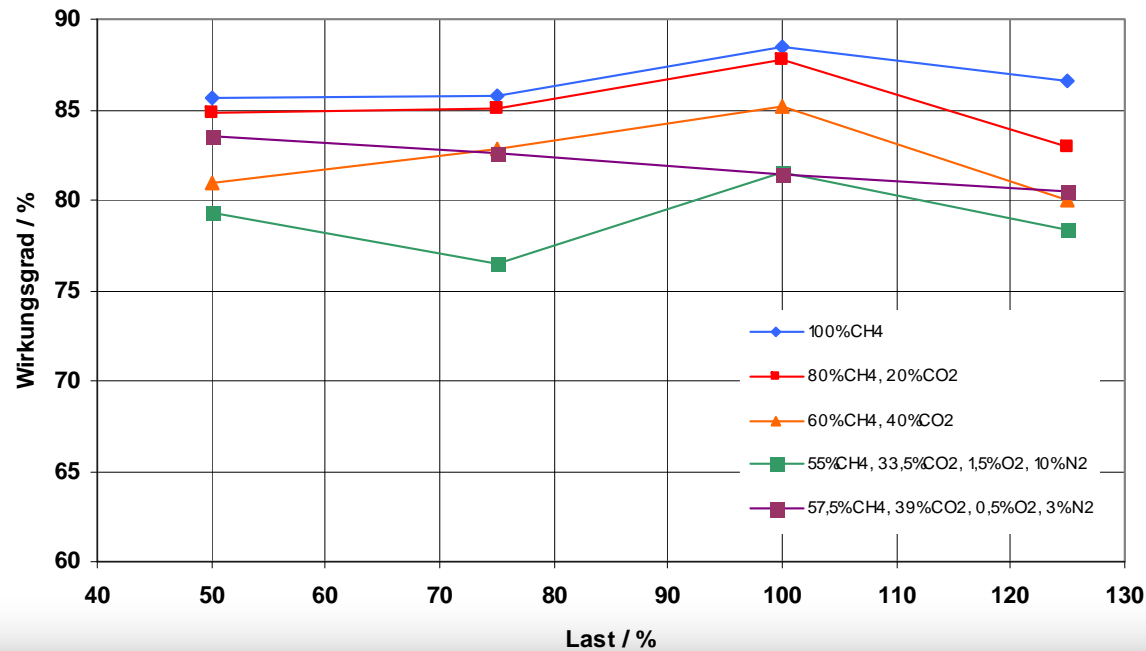


## Anpassungsentwicklung u. a. für EtOH

- Katalysatoruntersuchungen
- Systemintegration

### Basis: Dampfreformer für NG, LPG & Biogas

- Nennlast: 2,5 – 12,5 kW<sub>thH<sub>2</sub></sub>
- Wirkungsgrad: 75 – 85 %
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TÜV-geprüfte Anlage  
(V<sub>H<sub>2</sub></sub> = 3 m<sup>3</sup><sub>N</sub>/hr)



## Vielen Dank für Ihre Aufmerksamkeit

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